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Air Force Program Status on Lead Free Solder

U.S. AIR FORCE

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Outline

- Big Picture & Background
- Technical Issues
- Impact to DoD
- Risk To USAF Programs
- Who's Doing What?
- USAF Direction
- Future Activities
- Conclusion

Big Picture Perspective

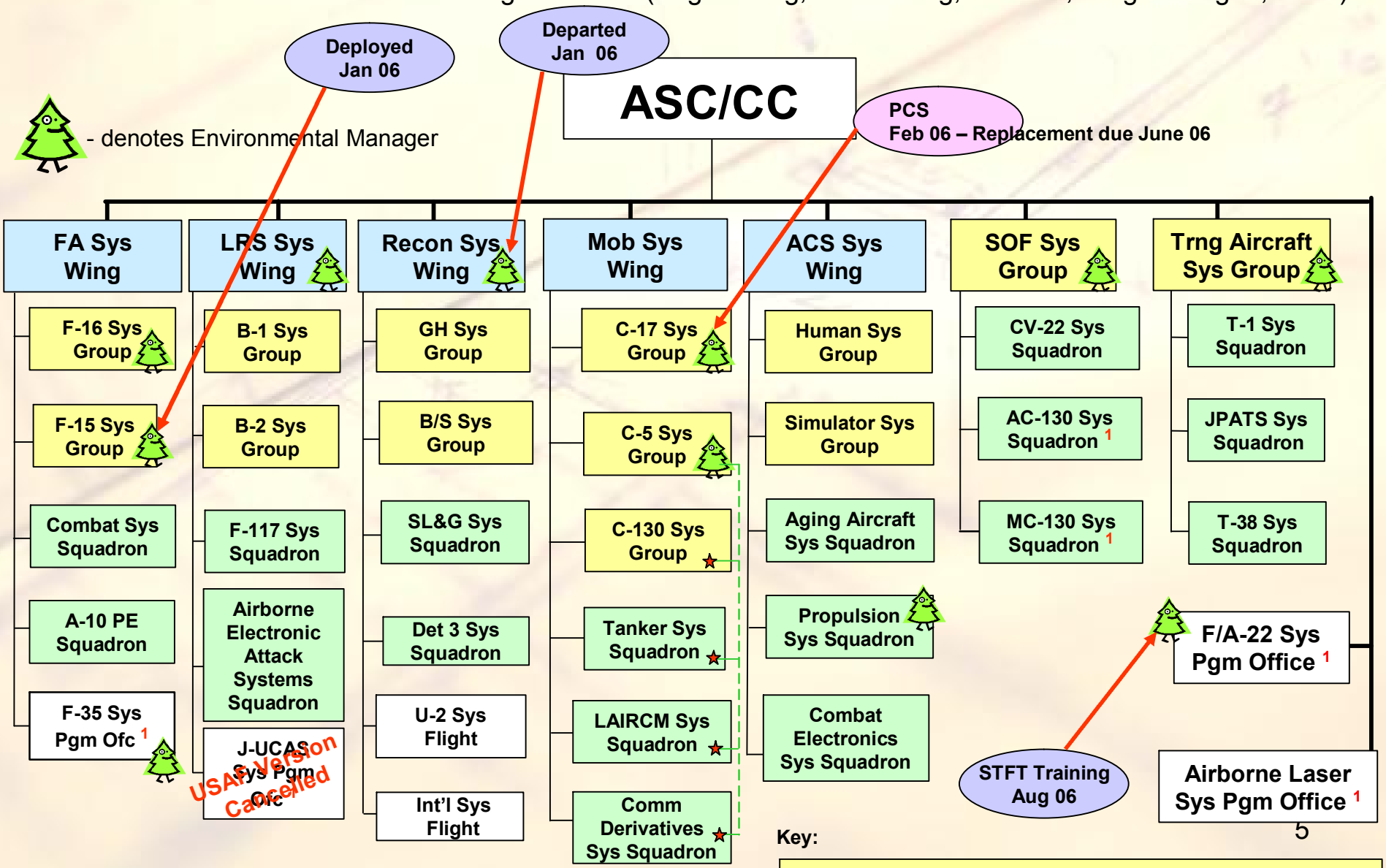
- USAF
  - Air Combat Command (ACC)
  - Air Mobility Command (AMC)
  - Air Education and Training Command (AETC)
  - Air Force Space Command (AFSPC)
  - Air Force Special Operations Command (AFSOC)
  - Air Force Reserve Command (AFRC)
  - Air Force Material Command (AFMC)
    - HQ AFMC Staff
    - Air Logistics Centers (ALCs) (AF Depot repair done here!)
      - OO-ALC, OC-ALC & WR-ALC
    - Field Operating Agencies
    - Laboratory
    - Specialized Centers
    - Test Centers
    - Mission Areas
    - **Product Centers**

Big Picture Perspective

- Product Centers
  - Space and Missile Systems Center (SMC)
  - Electronic Systems Center (ESC)
  - Aeronautical Systems Center (ASC)
    - » Located at Wright-Patterson AFB, Ohio
    - » Responsible for Development & Acquisition of Air Force Weapon Systems
    - » Recently Reorganized from System Program Offices (SPOs) to Wing/Group/Squadrons

ASC Organization Structure

Note: Not shown are the Functional Organizations (Engineering, Contracting, Finance, Program Mgmt, etc…)



Long Range Strike Systems Wing (LRSSW)

ASC/CC

LRSSW
Mr Chuck Jackson, SES Director
Col James Jolliffe, Deputy Director

- **B-1 Systems Group**
- **B-2 Systems Group**
- **F-117 Systems Squadron**
- **B-52 Systems Squadron**
- **J-UCAS Systems Program Division** — USAF Version Cancelled

- **EN** Engineering
- **FM** Finance
- **PK** Contracts
- **LG** Logistics

- **XR** Capability Integration
- **HR** Human Resources
- **OM** Management Operations
- **Security**

As of 22 Jun 05

LFS Background

- Global Electronics Marketplace Impact
- RoHS & WEEE Directives
- July 1, 2006
- Many US Companies already “Lead Free”
  - Motorola
- No US Legislation on LFS
- 3 Levels of Electronic Devices
  - Related to Testing Requirements
    - Level 1 – Consumer Electronics
    - Level 2 – Automotive
    - Level 3 – Aerospace/Military

Technical Issues

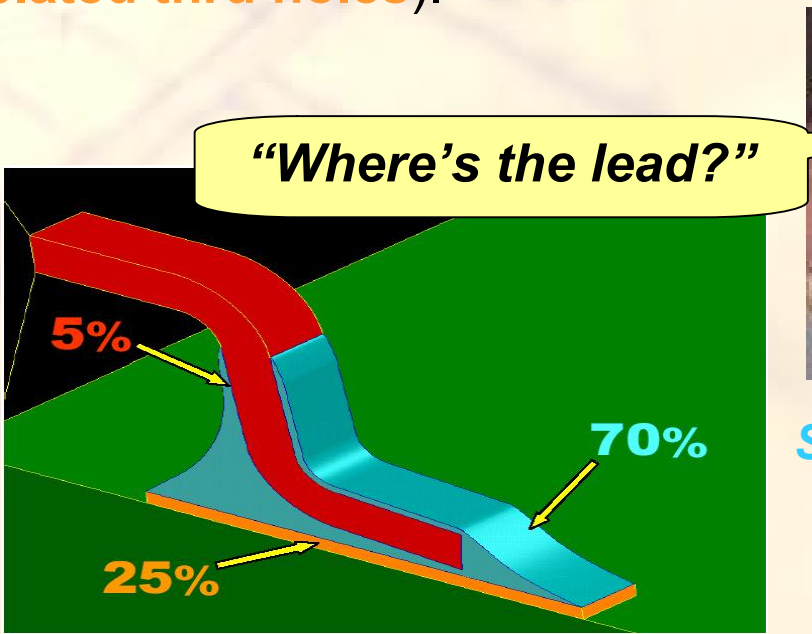
- Temperature
  - Melting point Higher for Lead Free Solders
- Compatibility Issues with mixed systems
- Popular Lead Free Solution – 100% Tin
  - Tin Plague or Tin Pest
  - Tin Whiskers
    - Occurs on Tin platings

Repair

Configuration Control

Solder Basics

- Solders perform three basic functions in electronics interconnection:
  - Applied to **component leads** to achieve a compatible solderable surface
  - Used to attach electronic components to printed circuit boards (e.g., **solder materials**)
  - Provide the final surface finish for printed wiring boards (e.g., **PWB pads and plated thru holes**).

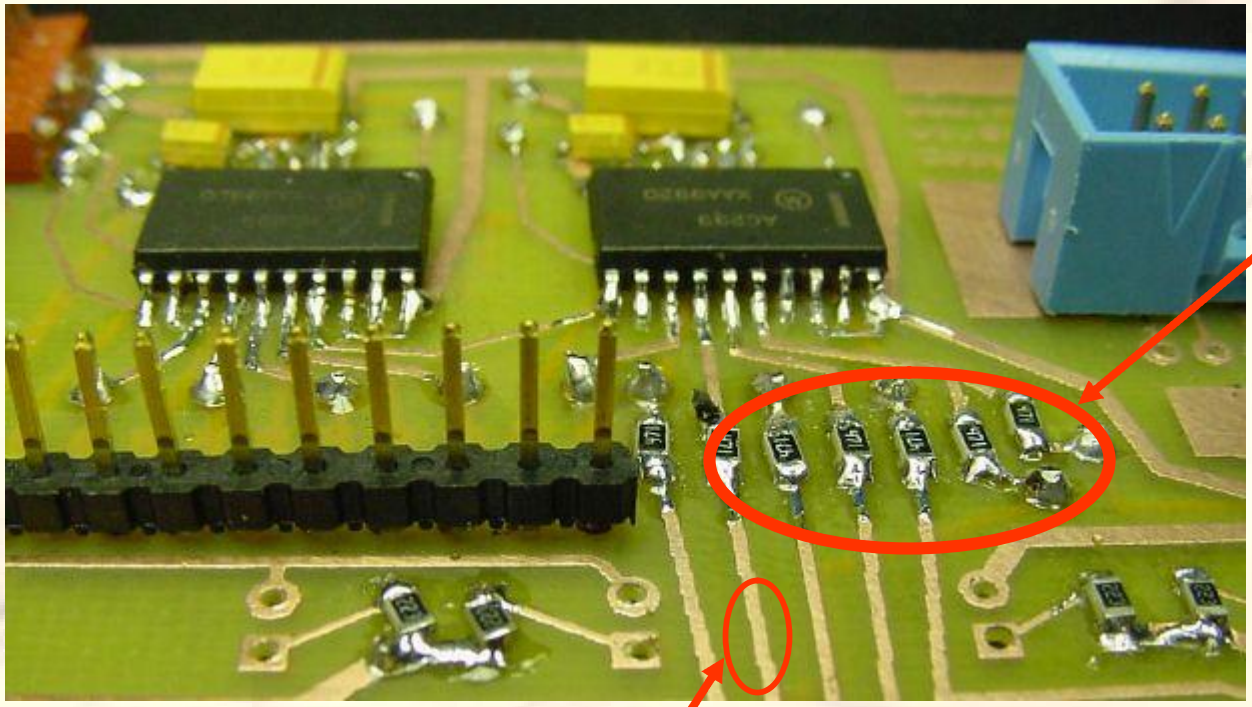


Component Lead Plating

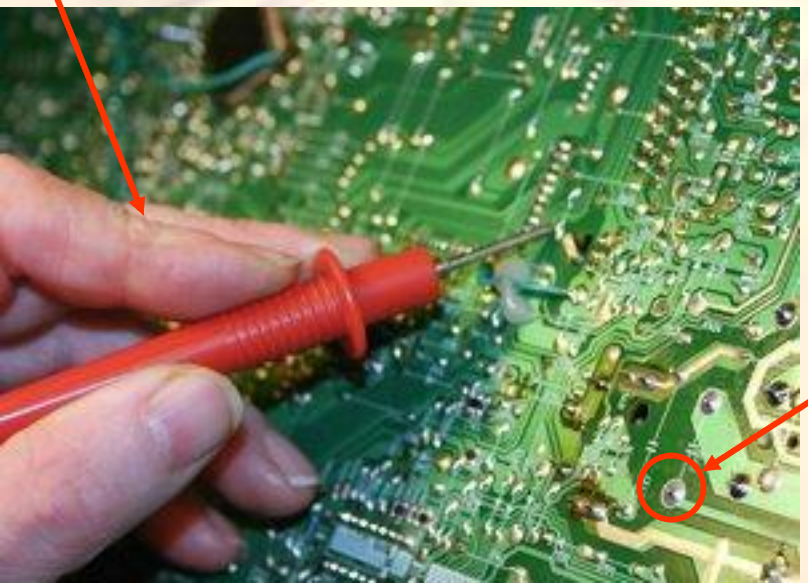
Solder Materials

PWB Pads and PTHs

Circuit Cards

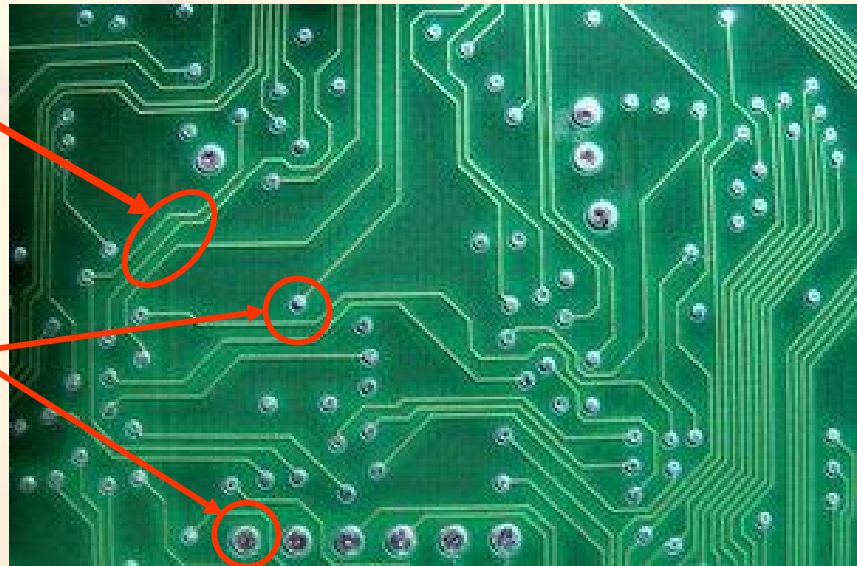


Finger



Trace

Pad



Impact to DoD

- **Aerospace/Military is 1% of the Global Electronics Market**
  - **You read, "We have no influence!"**
- **Army & Navy Missile Programs**
  - **Aware and restricting use of Lead Free Solder**
- **NASA**
  - **Fully engaged with Testing**
  - **Restricting use of Lead Free Tin Solder**

Risk To USAF Programs

- Development
  - Lead Free plated parts and assemblies “showing up” in new developments & new modifications
- Sustainment
  - Repair of “known and unknown” LFS parts
- Commercial of the Shelf (COTS) Assemblies
  - In both Development and Sustainment, do you know what you’re getting?

Risk To USAF Programs

$$

Improper Repair

Unknown $$

Requires Contractual Direction

Results in Mixed Configurations

Qual Testing to show Reliability

Prohibit Lead Free

Do Nothing

Allow Lead Free

DEVELOPMENT OPTIONS

Risk To USAF Programs

"All paths lead to…Sustainment"
-Mi Nuttsert
215 B.C.

Risk To USAF Programs

got COTS?

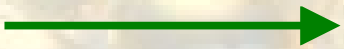
If you don't know what you have…

How do you properly repair?

If you *think* you know what you have…

How do you verify?

Component Suppliers
Marking Issues



Not Consistent
Non Existent
Not Reliable

Who's Doing What?

- Many Groups out there!
  - JCAA/JG-PP LFS Testing
  - LEAP Working Group *(Lead-free Electronics in Aerospace Products)*
    - AIA – AMC - GEIA
      - GEIA-STD-0005-1 – Lead-Free Plan **
      - GEIA-STD-0005-2 – Tin Whisker Mitigation **
      - GEIA-HB-0005-1 – PM Handbook **
      - GEIA-HB-0005-2 – Lead-Free Tech Guidelines
      - GEIA-HB-0005-3 – Lead Free Reliability Testing Guidelines
  - DoD ELF IPT
  - JDEC
  - IPC

** Released by GEIA in July 06

GEIA Documents

- **GEIA-STD-0005-1, Performance Standard for Aerospace and High Performance Electronic Systems Containing Lead-Free Solder**
  - This document is intended for use by aerospace and defense electronic systems customers, e.g., airframe integrators, military operators, and commercial airlines, to communicate requirements to aerospace and defense electronic system suppliers, e.g., aerospace electronics manufacturers. It is an objective-based document that states customer "care-abouts" in the form of objectives, and requires suppliers to document the process they will use to satisfy the objectives. Examples of objectives are quality and reliability, configuration control, repair, and rework.
- **GEIA-STD-0005-2, Standard for Mitigating the Effects of Tin Whiskers in Aerospace and High Performance Electronic Systems**
  - Although many aerospace and defense electronics manufacturers will continue to use tin-lead as an attachment alloy for printed wiring assemblies, they will be forced to use piece parts with lead-free alloy finishes, the most common of which is pure tin. Pure tin finishes promote growth of "tin whiskers", which can cause serious reliability problems in aerospace and defense systems. The technical details of tin whisker growth and control are not completely understood; but their effects must be controlled in aerospace and defense products. This standard provides a framework to do so. It is structured according to levels of mitigation, which are selected by aerospace and defense electronics manufacturers and users, based on the level of control required for the given application.
- **GEIA-HB-0005-1, Program Management / Systems Engineering Guidelines for Managing The Transition To Lead-Free Electronics**
  - This document provides guidance for program and systems engineering managers for managing the use of lead-free electronics. Programs may inadvertently introduce lead-free elements (including piece part finish, printed wiring board finish, or assembly solder) if careful coordination between buyer and supplier is not exercised. This handbook is designed to assist programs in assuring the performance, reliability, airworthiness, safety, and certifiability of product(s), in accordance with GEIA-STD-0005-1.

Who's Doing What?

- JCAA/JG-PP Project Status
  - Candidate Alternatives Chosen for Testing
    - Tin-copper (stabilized) (99.3Sn-0.7Cu-0.05Ni) for wave and manual soldering
    - Tin-silver-copper (95.5Sn-3.9Ag-0.6Cu) for wave, reflow and manual soldering
    - Tin-silver-copper-bismuth (92.3Sn-3.4Ag-1.0Cu-3.3Bi) for reflow and manual soldering
  - Testing
    - Vibration, Salt Fog & Humidity, Mechanical Shock, Thermal Shock, Thermal Cycling, Combined Environment Test
    - Nearly all of the Primary Testing is complete (Still running Thermal Cycle -20/+80^{o}C, will continue until all parts reach 100% failure ~ summer 2006?)
    - Still conducting Thermal Cycle (-55/+125^{0}C) testing on "Hybrid" Test Vehicles (Expected to complete summer of 2006)
    - Completed Testing indicates **"No Silver Bullet"**
      - **No Drop-In Replacement – all have issues**

Executive Lead-Free Integrated Process Team (ELF IPT)

- Senior Membership from:
  - DoD
  - DLA
  - Army
  - Navy
  - Air Force
  - Industry
- Identify DoD specific issues
  - Lead-free roadmap
  - Cost impacts
- Monitor service efforts
- Provide policy recommendations to DoD LF WG
- Identify research efforts

DoD Lead-Free Working Group

- Established at Dec 2005 ELF IPT meeting
  - First meeting Jan 2006
  - Formal charter being drafted
    - Formal Charter will allow group to:
      - Draft DoD Policy
      - Adopt Industry Documents
- Members from DoD and Government stakeholders
  - Army, Navy, Air Force, DLA, OSD, NASA, FAA
- Receives inputs from ELF IPT and LEAP-WG
- Provides coordinated DoD lead-free response
  - Policy
  - Technical Guidance
  - Technology investment
  - Science projects

USAF Direction

- Airworthiness Advisory from ASC/EN
  - Summary:
    - Lead-free solder considered a flight safety issue
    - Move to Pb-free can create manufacturing and operational complications
    - Mention of Joint Council on Aging Aircraft project
  - Issued May 05 to ASC Technical Leadership chain
  - Drafted by Capt Drew Clewett (F-15 Env Mgr)
  - Raised Awareness of the issue

USAF Direction

- Airworthiness Advisory Recommendations
  - Stay away from lead-free solder
    - Several lead-free solder initiatives, none have passed reliability testing
  - Program Managers to ensure OEMs/suppliers provide leaded solder systems
  - Incorporate industry standard IPC-1066 for purchasing/repair requirements in contracts
    - Identification (i.e., marking, symbols, and labels) of any lead-free solder systems
  - Lead-free solder components/assemblies not always marked
  - Further testing/inspection of electronic systems needed

Future Activities

- Lead Free Finishes, Parts, Components and Assemblies will continue to become part of the DoD inventory
- Adoption of LEAP Documents
- DoD Policy Letter

- …Stay Tuned for More!

Conclusion

- AF will have to address Lead Free Systems
- AF Contractors and Subs more aware and taking action to be prepared
- Depot Repair risks remains a concern
- The USAF isn't ready to adopt LFS Processes!


Questions?
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Backup Slides

Circuit Components

- **CLCC-20 -** Ceramic Leadless Chip Carrier
- **PLCC-20 –** Plastic Leaded Chip Carrier
- **TSOP-50 -** Thin Small Outline Package
- **TQFP-144 –** Thin Quad Flat Pack
- **TQFP-208 –** Thin Quad Flat Pack **
- **PBGA-225 –** Plastic Ball Grid Array
- **PDIP-20** – Plastic Dual Inline Package
- **BGA** – Ball Grid Array
- **PTH** – Plated Through Hole
  - ****Note:** significance of "-208" – the numerical suffix denotes the # of pins on the package!